Eur Arch Otorhinolaryngol (2009) 266:1159–1165
DOI 10.1007/s00405-008-0842-2

OTOLOGY

Cochlear implantation in patients with chronic otitis media: 7 years' experience in Maastricht

Job T. F. Postelmans · Robert J. Stokroos · Joris J. Linmans · Bernd Kremer

Received: 2 May 2008 / Accepted: 4 October 2008 / Published online: 4 November 2008

Abstract The purpose of this paper is to propose management options for cochlear implantation in chronicotitis media (COM) based on our 7-year experience. Thirteen patients with COM who were candidates for cochlear implantation were identified. COM was divided in an inactive and an active form based on clinical and radiological findings. One major complications and one minor complication were identified in the study group. In case of an active infection or in case of a unstable cavity we advise cochlear implantation as a staged procedure. A single stage procedure is recommended in case of patients with COM presenting with a dry perforation or a stable cavity.

Keywords Cochlear implantation · Chronic otitis media · Complications

Introduction

During the past three decades cochlear implantation is accepted as a safe and effective method of audiological rehabilitation for the profoundly hearing-impaired deaf adult or child, who derives insufficient benefit from conventional hearing aids. Some patients suffering severe to profound sensorineural hearing loss as a result of chronic otitis media (COM) might be candidates for cochlear implantation. In these patients, COM plays a role in the aetiology of the hearing loss but may limit possibilities for hearing rehabilitation at the same time. Cochlear implantation in a chronic diseased ear may lead to implant colonization and subsequent implant extrusion or meningitis as a consequence of inserting an electrode through an infected mastoid or middle ear cavity into a space with intracranial communication.

The degree of the activity of the disease has influence on the cochlear implant strategy in patients with a chronic diseased ear. COM can be distinguished on clinical and radiological characteristics into an active (with or without cholesteatoma) or an inactive form. Regarding the inactive form with a simple dry perforation, placement of the cochlear implant and closing of the dry tympanic membrane perforation can be performed as a single stage procedure. In case of an active infection (with or without cholesteatoma), it is debated in the literature whether a single stage or a two-stage procedure is preferable and which surgical technique should be used. In all patients with COM, recurrence of a cholesteatoma and/or flaring-up of the infection are the main issues of concern.

In this paper we report our surgical complications after cochlear implantation in patients with a history of COM. Second, we describe an algorithm which we used for managing cochlear implantation in patients with COM in this study.

Materials and methods

The charts of all 156 consecutive patients who underwent cochlear implantation between January 2000 and January 2007 at our tertiary referral hospital in Maastricht were retrospectively reviewed after institutional review board's approval was obtained. An assessment of all 156 patients showed that there was an overlap of the patient population

J. T. F. Postelmans (✉) · R. J. Stokroos · J. J. Linmans · B. Kremer
Department of Otolaryngology-Head and Neck Surgery,
Maastricht University Medical Centre, P. Debyelaan 25,
P.O. Box 5800, 6202 AZ Maastricht, The Netherlands
e-mail: JobPostelmans@gmail.com

which was discussed in our former paper [1]. From June 2005 till January 2007 we collected another 44 patients, who underwent cochlear implantation. Regarding our former paper, there is an overlap of 44 patients, three of whom were identified as suffering from COM. All implantations were performed by the same surgeon. Candidates for cochlear implantation were evaluated for COM by a careful review of their otological case history, by otoscopy, by tympanometry, and actual imaging (CT and/or MRI). All patients had a double-sided progressive hearing loss with PTA $\geq$ 90 dB and SDS $\leq$ 30%; therefore all patients were not considered as candidates for middle-ear prosthesis due to their lack of residual hearing. Patients who were found to have a history of COM preceding cochlear implantation were enrolled in this study. The inactive forms of COM were defined as having a history of COM with otoscopic evidence, e.g., myringosclerosis or tympanic membrane perforation, but no clinical or radiological evidence of any infectious activity 6 months prior to implantation. Active forms of COM were defined as having a history of COM with clinical and radiological signs of either a recent or current infection with or without a cholesteatoma 6 months prior to implantation.

Clinical charts were reviewed for medical history, aetiology of hearing loss, type of cochlear implant and electrode, surgical management of the implanted ear and postoperative complications. In keeping with the classification of Cohen and Hofmann [2], "Major" complications were defined as those requiring further surgery, and/or hospitalization for treatment. "Minor" complications were identified as those that can be overcome by medical or audiological management and cause little distress to the patient.

Preoperative audiological assessment included pure-tone audiometry (PTA) and speech discrimination tests (SDT) by means of a monosyllabic word list in Dutch. Pure-tone average (PTA) was calculated as the average of the thresholds at 0.5, 1, 2 and 3 kHz.

Surgical management

All study patients received antibiotic therapy based on ear swabs preoperatively and were postoperatively continued for 7–10 days. Cases with an inactive or active COM with or without cholesteatoma were identified and treated according to the following algorithm (Fig. 1).

- In patients presenting with an inactive form with a simple dry perforation, placement of the cochlear implant and closing of the dry tympanic membrane perforation was performed as a single stage procedure.
- In patients having a pre-existing radical mastoid cavity (RMC) without (a history of) evidence for an active inflammation, cochlear implantation was performed with a subtotal petrosectomy as a single stage procedure.
- In patients having a pre-existing RMC with evidence for an active inflammation, cochlear implantation was performed as a staged procedure 3–6 months after subtotal petrosectomy.
- In patients presenting with an active COM with or without cholesteatoma, cochlear implantation was performed as a staged procedure 3–6 months after either a combined approach tympanotomy with posterior tympanotomy or subtotal petrosectomy.

Surgical technique

All cochlear implants were implanted by the posterior tympanotomy approach using standard surgical techniques in case of an inactive COM with a dry tympanic membrane perforation. With respect to patients with a pre-existing RMC or an active COM (with or without cholesteatoma) a subtotal petrosectomy was performed. A subtotal petrosectomy is a complete eradication of all pneumatic cell tracts of the temporal bone, except for a few remnants of the apical cells when present, with obliteration of the isthmus of the Eustachian tube and blind sac closure of the external canal. Obliteration of the tympanomastoid cavity is performed with abdominal fat or a pedicled temporalis muscle flap.

In this study the surgical procedure is performed in the following order in case of patients with a pre-existing RMC or an active COM:

(1) retroauricular incision with development of a musculo-periosteal flap, (2) subtotal petrosectomy, (3) obliteration of the Eustachian tube opening, (4) blind sac closure of the external auditory canal, (5) drilling the well to accommodate the receiver-stimulator package, (6) cochleostomy, (7) insertion and fixation of the cochlear implant using muscle flaps and fibrin glue at cochleostomy. Furthermore, fibrin glue is used to fixate the electrode near the posterior wall of the mastoid cavity. (8) The tympanomastoid cavity is filled with abdominal fat to cover the electrode. (9) The musculo-periosteal flap is sutured over the receiver-stimulator and petrosectomy cavity so that the receiver is fixated and the fat is contained under the flap. (10) Finally, the subcutaneous soft tissue and skin are closed in two layers.

Results

From January 2000 till September 2006, 156 patients underwent cochlear implantation. Thirteen patients (8.3% 13/156) were identified with COM.

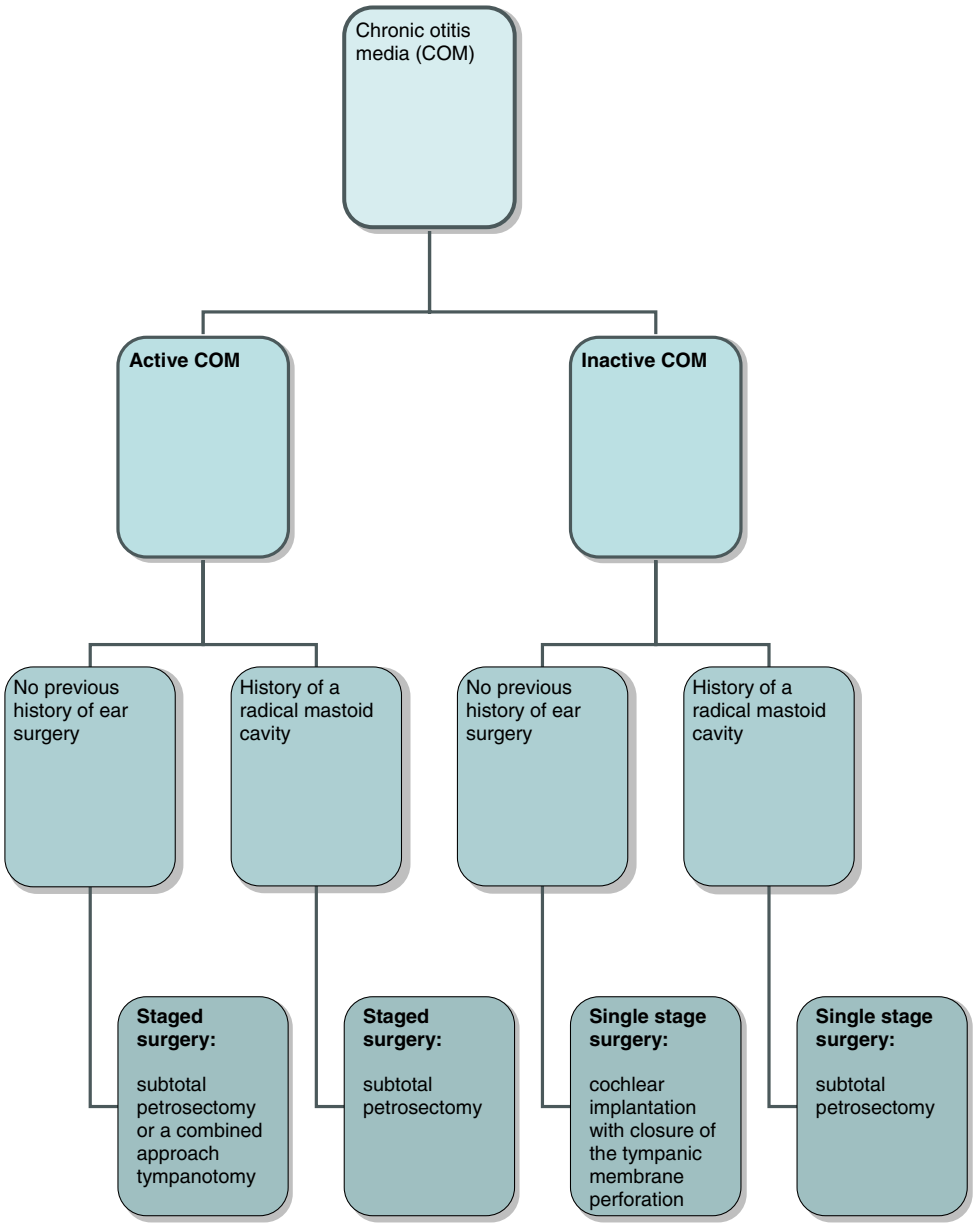

Fig. 1 Depicts the algorithm which was used in case of cochlear implantation in patients with or without active chronic otitis media

This study group consisted of six males and seven females. Mean age at implantation was 60.9 years (range 29–77 years). The demographic characteristics of patients with COM receiving a cochlear implant are summarized in Tables 1 and 2. Five patients were identified with COM without a history of prior ear surgery. Two of them had an active inflammation with cholesteatoma. Both patients underwent a combined approach tympanotomy with posterior tympanotomy to eradicate the cholesteatoma prior to cochlear implantation. The remaining three patients had clinical and radiological inactive form of COM. In those three patients, a single staged cochlear implantation and closure of the tympanic membrane perforation was carried out via a standard combined approach/facial recess technique.

Eight patients with COM presenting with a RMC were enrolled in this study. Six patients without active COM underwent a subtotal petrosectomy and cochlear implantation as a single stage procedure. Two patients presented with a clinical and radiological active inflammation and received their cochlear implant 6 months after performing a subtotal petrosectomy. In one case a cholesteatoma was identified during surgery. In all patients with a RMC, no intra- or postoperative complications were encountered.

Major complications

One major complication (7.7% 1/13) was identified in one patient who received the cochlear implant during a single stage procedure. This patient had no clinical or radiological

Table 1 shows the characteristics of the number of study patients

Patients	Sex	Age	Medical history	Active or inactive	Cholesteatoma	Staged	CAT	Subtotal petrosectomy	Major complication	Minor complications
1	Female	71	COM	Inactive	No	No	No	No	Yes	No
2	Male	56	COM	Active	Yes	Yes	Yes	No	No	No
3	Female	44	COM	Inactive	No	No	No	No	No	No
4	Male	71	COM	Active	Yes	Yes	Yes	No	No	No
5	Female	67	COM	Inactive	No	No	No	No	No	Yes
6	Male	46	RMC	Inactive	No	No	No	Yes	No	No
7	Male	52	RMC	Inactive	No	No	No	Yes	No	No
8	Female	29	RMC	Inactive	No	No	No	Yes	No	No
9	Female	76	RMC	Inactive	No	No	No	Yes	No	No
10	Male	77	RMC	Inactive	No	No	No	Yes	No	No
11	Female	62	RMC	Active	Yes	Yes	No	Yes	No	No
12	Female	74	RMC	Inactive	No	No	No	Yes	No	No
13	Male	63	RMC	Active	No	Yes	No	Yes	No	No

Table 2 Shows the characteristics of the number of study patients with respect to preoperative audiological assessments and type of implants

Patients	Sex	Age	Medical history	Type of implant	Array design	PTA operated ear (dB)	PTA contra-lateral ear (dB)	SDS operated ear (%)	SDS contra-lateral ear (%)
1	Female	71	COM	CI24R	Perimodiolar	NR	95	0	20
2	Male	56	COM	CI24R	Perimodiolar	NR	100	0	18
3	Female	44	COM	Helix 90 K	Perimodiolar	NR	110	0	10
4	Male	71	COM	CI24RCA	Perimodiolar	NR	NR	0	0
5	Female	67	COM	CI24RCA	Perimodiolar	NR	98	0	16
6	Male	46	RMC	Helix 90 K	Perimodiolar	NR	100	0	15
7	Male	52	RMC	CI24RCA	Perimodiolar	NR	NR	0	NR
8	Female	29	RMC	CI24RCA	Perimodiolar	NR	NR	0	NR
9	Female	76	RMC	Helix 90 K	Perimodiolar	100	95	15	20
10	Male	77	RMC	CI24RECA	Perimodiolar	NR	97	0	18
11	Female	62	RMC	CI24RECA	Perimodiolar	105	NR	0	0
12	Female	74	RMC	CI24RECA	Perimodiolar	NR	90	0	23
13	Male	63	RMC	CI24RECA	Perimodiolar	NR	100	0	20

NR no response

evidence for an active inflammation in the last 6 months prior to cochlear implantation.

The patient identified with a major complication was a 70-year-old woman who had a perceptive deafness due to COM. Since 1993 she has been audiometric deaf bilaterally. Subsequently, cochlear implantation and closure of the tympanic membrane perforation was performed as a single stage procedure. Pre- and peroperatively, no active inflammation or cholesteatoma was present. Three months after cochlear implantation, this patient complained about pain in the implant site attributed to a skin infection. Initially, the skin infection was treated with intravenous antibiotics. Exploration was done when antibiotic therapy failed. The cochlear implant was rotated cranially under the musculus temporalis. Due to persistent wound infection in combination with flaring up of the COM, wound dehiscence occurred and the implant package extruded. With the consent of the patient, the implant was explanted. No re-implantation has been carried out so far.

One patient needed 6 months after cochlear implantation further surgery due to a luxation of the implant induced by a fall of this patient. Replacement of the implant was carried out accompanied with no postoperative complications. Audiometric outcome was retained. This incident was not interpreted as a surgical complication because of its traumatic origin.

Minor complications

In one case, a minor complication developed which revealed an otitis externa. A 67-year-old female with an inactive COM, who had no clinical or radiological evidence for an active inflammation at time of operation, received her cochlear implant by means of a single stage procedure. She suffered from otitis externa one year after cochlear implantation. Local antibiotic therapy was required to break down the infection.

Discussion

The question whether cochlear implantation, in patients with an inactive COM with or without previous ear surgery, has to be performed as a staged or single staged procedure remains still unanswered. All surgeons fear a severe infection by inserting an electrode into the cochlea through a potentially infected field and thereby infecting a space which communicates intracranially. Reports on complications which required surgical treatment after cochlear implantation in patients with a stable COM are rare although some cases can be found. [3–5] The complications include recurrence of cholesteatoma [3], explantation of the implant due to severe inflammation [3, 4], wound breakdown [5], retraction pocket exposing the electrode array [3], or extrusion of the implant side due to flap difficulties [5]. All of these cases were as a consequence of flaring up of the infection which all required subsequent surgical treatment. Interestingly, all complications occurred after either single-staged or staged procedures. In this study, the low complication rate in this group is in keeping with the results reported in literature [6–10]. One of nine patients developed a major complication in this group. This patient had prior to cochlear implantation no clinical or radiological signs of inflammation. Six months after surgery a skin infection occurred, induced by flaring up of the inflammation. This case illustrates that there is still a possibility of serious complications and subsequent explantation which can develop in patients with an inactive COM. Although one major complication developed in this group, in our opinion it is still relatively safe to implant a cochlear implant as a single-stage procedure in patients with an inactive COM.

In contrast, cochlear implantation as a single-staged procedure in patients with an active COM is in our opinion obsolete. This is substantiated in literature where all authors plead for a staged procedure concerning this issue [2–7]. In this study, all patients with an active COM with or without previous ear surgery underwent complete eradication of the inflammation focus 6 months prior implantation by means of a combined approach tympanotomy with posterior tympanotomy in the latter. With respect to patients with an active COM accompanied known with previous ear surgery underwent a subtotal petrosectomy 6 months prior to cochlear implantation.

A subtotal petrosectomy implies the complete exenteration of all accessible air-cell tracts of the temporal bone, sealing the Eustachian tube orifice and closure of the external meatus. This may be followed by obliteration of the tympanomastoid cleft with a pedicled temporalis flap or with abdominal fat [11, 12]. In this study, lack of complications using a subtotal petrosectomy in patients with a preexisting radical mastoid cavity is in keeping with other published data. Gray et al. ($n = 4$), Axon et al. ($n = 4$), and Hamzavi et al.($n = 8$) reported no major complications after obliteration of the middle ear cleft with blind pit closure of the ear canal after 5 years [11, 13, 14]. Gray reported a residue of cholestatoma which was removed during the second operation. Eventually the cochlear implant could be implanted safely without further evidence for relapse of cholestatoma. In contrast, Issing et al. ($n = 12$) reported inadequate closure of a retroauricular fistula over the mastoid cavity in two cases (14.2%) and an inflammatory reaction in the implanted ear at 2 months in one case (7.1%) after cochlear implantation [15]. The inflammatory reaction was induced by a tumefactive inflammatory pseudotumor. Furthermore, Issing et al. [15] reported one patient with a temporary facial palsy for 2 weeks. The occurrence of a retroauricular fistula might be a consequence of impaired blood flow induced by prior retroauricular incisions or recurrence of cholesteatoma. Therefore this complication is not specific with respect to a subtotal petrosectomy.

Although the number of studied patients in literature is too small to have strong implications on the role of a subtotal petrosectomy in patients with COM undergoing cochlear implantation, the overall results in literature with respect to the combination cochlear implantation and subtotal petrosectomy are encouraging [11, 13–15].

In this study, the tympanomastoid cleft of all patients that underwent a subtotal petrosectomy was obliterated with abdominal fat. Fat has a low metabolic rate and will undergo fibrosis easier than necrosis. Because it is a large single mass, it is easy to be lifted off the promotorium in case of a second look which can be difficult after the use of other materials. The aim of obliterating the tympanomastoid cleft is to create a closed and sterile cavity reducing the risk of infection associated with inserting a foreign body. Furthermore, obliteration of the tympanomastoid cleft provides the patient with an isolated and sterile environment which lowers the risk of an infection induced by insertion of a foreign body. Another advantage of this procedure is that no life-long care of the particular ear is necessary and swimming is allowed. However, the procedure has to be carried out with utmost care to prevent a residue of epithe-

lial cells in the tympanomastoid cavity which can cause a recurrence of cholesteatoma inducing an asymptomatic destruction of the temporal bone with consecutive device failure. Second, if not all mucosa is removed a mucocele may develop, neccessitating re-exploration. A major drawback of this technique is the difficulty to facilitate radiological imaging and a second look to detect a recurrent cholesteatoma. To overcome this issue the tympanomastoid cavity can be left open.

Besides the subtotal petrosectomy, several surgical techniques to insert a cochlear implant in patients with COM with a RMC are described in literature [11, 12, 16–18]. Three other alternative surgical approaches are reported in literature which can be carried out either combined with cochlear implantation, as a single-stage procedure or as a staged procedure. The first approach is a revision mastoidectomy with eradication of active inflammation from the mastoid bowl and obliteration of the mastoid bowl with bone chips, with reconstruction of the bony posterior wall [17]. This technique contributes to the anatomic rehabilitation of the cavity if there is no protection of the electrode array by the tympanic membrane and bony posterior wall of the external auditory canal. The advantages of this procedure are (1) the electrode is protected from cavity problems such as chronic infection or erosion of the epithelium in the open mastoid cavity, and (2) reconstruction of the new tympanic cavity and tympanic membrane is beneficial to avoid electrode exposure in the mastoid and tympanic cavity. Regarding postoperative complications, inclusion of epithelial debris, necrosis of the cutaneous layer, or obliteration material and electrode migration in the cavity can develop. Therefore, this technique is not included in our algorithm.

The second is a revision mastoidectomy with removal of all epithelium from the mastoid bowl with creating a periosteal flap to cover the electrode. This is often combined with drilling a groove in the mastoid cavity to stabilize the electrodes, and cochlear implantation with stabilization of electrodes to the facial ridge with either bone cement or cartilage [12]. The advantages of this technique are (1) relapsing cholesteatoma can be effectively monitored, because of the benefits of an open technique. (2) The cement provides stabilization of the electrode array and the periosteal flaps provide a total covering of the electrode array, keeping it isolated from possible external contamination. However, this technique is not without risk of electrode exposure or migration, and is therefore also not included in our algorithm.

Third, using a middle fossa approach access to the cochlea bypassing the possible infected conventional route for cochlear implantation [19]. The electrode is inserted through a basal turn cochleostomy created in the floor of the middle cranial fossa. In this approach the cochleostomy is created further along the basal turn and the electrode may be inserted deeper in the cochlea. Whether this has a negative effect on hearing outcome remains to be demonstrated. The possible drawbacks of this procedure are the inherent risks of a craniotomy and compression of the temporal lobe.

Conclusion

In our opinion, for patients with evidence for an active COM with or without cholesteatoma cochlear implantation has to be performed as a staged procedure. In patients with COM with a dry perforation or a stable cavity, cochlear implantation can be performed as a single stage procedure. Although it is accepted that cochlear implantation is relatively safe, especially in patients with a stable COM, our results illustrate that there is still a chance for serious complications in which subsequent explantation of the cochlear implant is desired.

Conflict of interest statement All authors declare that there is no financial relationship with any type of organization that might have sponsored this research.

References

1. Postelmans JT, Cleffken B, Stokroos RJ (2007) Postoperative complications of cochlear implantation in adults and children: five years' experience in Maastricht. J Laryngol Otol 121:318–323. doi:10.1017/S0022215106003471
2. Cohen NL, Hoffman R (1991) Complications of cochlear implant surgery in adults and children. Ann Otol Rhinol Laryngol 100:708–711
3. Bhatia K, Gibbin KP, Nikolopoulos TP et al (2004) Surgical complications and their management in a series of 300 consecutive pediatric cochlear implantations. Otol Neurotol 25:730–739. doi:10.1097/00129492-200409000-00015
4. Harada T, Ishida K, Endo M et al (2003) Recurrent extrusion of cochlear implant at an interval of 5 years. Otol Neurotol 24:83–85. doi:10.1097/00129492-200301000-00017
5. Donnelly MJ, Pyman BC, Clark GM (1995) Chronic middle ear disease and cochlear implantation. Ann Otol Rhinol Laryngol Suppl 166:406–408
6. Syms MJ, Luxford WM (2003) Management of cholesteatoma: status of the canal wall. Laryngoscope 113:443–448. doi:10.1097/00005537-200303000-00010
7. Roberson JB Jr, Mason TP, Stidham KR (2003) Mastoid obliteration: autogenous cranial bone pate reconstruction. Otol Neurotol 24:132–140. doi:10.1097/00129492-200303000-00002
8. Mills RP (1988) Surgical management of the discharging mastoid cavity. J Laryngol Otol Suppl 16:1–6
9. Palva T (1988) Surgical treatment of chronic middle ear disease. III. Revisions after tympanomastoid surgery. Acta Otolaryngol 105:82–89. doi:10.3109/00016488809119449

10. Sheehy JL (1988) Cholesteatoma surgery: canal wall down procedures. Ann Otol Rhinol Laryngol 97:30–35
11. Gray RF, Irving RM (1995) Cochlear implants in chronic suppurative otitis media. Am J Otol 16:682–686
12. Meyerhoff WL, Stringer SP, Roland PS (1988) Rambo procedure: modification and application. Laryngoscope 98:795–796
13. Axon PR, Mawman DJ, Upile T, Ramsden RT (1997) Cochlear implantation in the presence of chronic suppurative otitis media. J Laryngol Otol 111:228–232. doi:10.1017/S0022215100136977
14. Hamzavi J, Baumgartner W, Franz P, Plenk H (2001) Radical cavities and cochlear implantation. Acta Otolaryngol 121:607–609
15. Issing PR, Schonermark MP, Winkelman S et al (1998) Cochlear implantation in patients with chronic otitis: indications for subtotal petrosectomy and obliteration of the middle ear. Skull Base Surg 8:127–131
16. El-Kashlan HK, Arts HA, Telian SA (2002) Cochlear implantation in chronic suppurative otitis media. Otol Neurotol 23:53–55. doi:10.1097/00129492-200201000-00013
17. Tamura Y, Shinkawa A, Ishida K et al (1997) Cochlear implant after reconstruction of the external bony canal wall and tympanic cavity in radically mastoidectomized patients with cholesteatoma. Auris Nasus Larynx 24:361–366. doi:10.1016/S0385-8146(97)10001-3
18. Manrique M, Cervera-Paz FJ, Espinosa JM et al (1996) Cochlear implantation in radical cavities of mastoidectomy. Laryngoscope 106:1562–1565. doi:10.1097/00005537-199612000-00024
19. Colletti V, Fiorino FG, Carner M et al (1998) Basal turn cochleostomy via the middle fossa route for cochlear implant insertion. Am J Otol 19:778–784